SSM/I OCEANIC RAINFALL VARIABILITY

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FINAL REPORT
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Scientific Objective

Use global satellite microwave data from the Special Sensor Microwave Imager (SSM/I) to identify seasonal, regional, and morning-evening differences in areal extent, intensity, and character of oceanic precipitation.

Summary of Work Completed

This report summarizes work accomplished during a two year grant to use SSM/I data to study the temporal, spatial, and physical characteristics of precipitation over the global oceans.

During the early part of the project period, we screened approximately 1.5 years of SSM/I data (July 1987 — December 1988) for all over-ocean pixels with normalized 37 GHz polarizations $P_{37} < 0.5$. In our analysis, the P_{37} threshold was assumed to select pixels with *significant fractional coverage by liquid precipitation* within the satellite field-of-view (FOV), while large values of S_{85} are assumed to indicate the presence of *large-diameter ice particles aloft*, as would be expected primarily in convection. By contrast, a small or negative value of S_{85} is taken to be indicative of warm rain.

Using these simple interpretations of the above two physically distinct indices, we inferred the following properties of oceanic precipitation:

- Globally, precipitation of all types is typically ~10% more frequent near 0600 than near 1800 LST over the open ocean, with the difference being most consistently positive in the tropics and subtropics. Maps do not reveal any systematic relationship between this ratio and the position of major land masses.
- Globally, the *convective character* index is substantially larger (up to ~40%) during morning hours than during the evening hours. The larger the S_{85} threshold used in defining this index, the greater the AM/PM difference.
- Maps of the convective character index reveal surprisingly sharp delineations between regions dominated by deep convection and regions dominated by (presumably) weaker stratiform precipitation. Similar differences were noted in the relative predominance of apparent warm rain.

Selected examples of the above results were included in a conference paper presented at the 7th Conference on Satellite Meteorology and Climatology (Petty 1994).

Prior to final publication of the above results, independent verification, and possible fine tuning, of at least some aspects of the satellite-derived precipitation frequencies was deemed necessary. This led to a major effort to analyze a 34 year (1958–1992) subset of the COADS surface ship data set in order to generate a unique global climatology of over-ocean precipitation frequency and character (i.e., phase, qualitative intensity) for comparison with the satellite derived precipitation frequencies. This analysis has now been completed and accepted for publication in the *Bulletin of the American Meteorological Society* (Petty 1995).

In addition to the above work bearing directly on the originally stated goals of the proposal, a number of other papers more generally related to the problem of precipitation estimation from microwave sensors were published by the PI (see list below), supported in part by this NASA grant. Also, student David Stettner completed his M.S. thesis on the validation of the Petty (1994) rain rate algorithm against surface radar and atoll rain gauge data. This work was also presented at the 7th Conference on Satellite Meteorology and Climatology (Petty and Stettner 1994). Final journal publication is being delayed until results from the 2nd Precipitation Intercomparison Project (PIP-2) and the 3d Algorithm Intercomparison Project (AIP-3) become available and can be included.

Further work on rain rate algorithms and on the empirical study of global rainfall distributions is continuing under a new NASA grant (NAGW-3944).

Other Relevant Activities and Accomplishments

- Participated in the first and second Precipitation Intercomparison Projects (PIP-1, PIP-2) and in the 2nd and 3d Algorithm Intercomparison Projects (AIP-2, AIP-3).
- Appointed to the Steering Committee for the WetNet 3d Precipitation Intercomparison Project (PIP-3).
- Selected to co-chair the upcoming 8th Conference on Satellite Meteorology and Oceanography.
- Appointed to a three-year term on the Scienfic Advisory Team to the WMO Global Precipitation

Climatology Project.

Relevant Journal Publications during Project Period ('*' indicates publications explicitly acknowledging support from NASA grant NAGW-2984, copies of which are included with this report).

Petty, G.W., and K.B. Katsaros, 1994: The response of the SSM/I to the marine environment. Part II: A parameterization of the effect of the sea surface slope distribution on emission and reflection. *J. Atmos. Ocean. Tech.*, **11**, 617–628

* Petty, G.W., 1994: Physical retrievals of over-ocean rain rate from multichannel microwave imagery. Part I: Theoretical characteristics of normalized polarization and scattering indices. *Meteorol. Atmos. Phys.*, **54**, 79–100 (invited paper)

* Petty, G.W., 1994: Physical retrievals of over-ocean rain rate from multichannel microwave imagery. Part II: Algorithm implementation. *Meteorol. Atmos. Phys.*, **54**, 101–122 (invited paper)

Wilheit, T., R. Adler, S. Avery, E. Barrett, P. Bauer, W. Berg, A. Chang, J. Ferriday, N. Grody, S. Goodman, C. Kidd, D. Kniveton, C. Kummerow, A. Mugnai, W. Olson, G. Petty, A. Shibata, E. Smith, R. Spencer, 1994: Algorithms for the retrieval of rainfall from passive microwave measurements. *Remote Sens. Rev.*, **11**, 163–194

Barrett, E.C., R.F. Adler, K. Arpe, P. Bauer, W. Berg, A. Chang, R. Ferraro, J. Ferriday, S. Goodman, Y. Hong, J. Janowiak, C. Kidd, D. Kniveton, M. Morrissey, W. Olson, G. Petty, B. Rudolf, A. Shibata, E. Smith, R. Spencer, 1994: The first WetNet Precipitation Intercomparison Project: Interpretation of results. *Remote Sens. Rev.*, **11**, 303–373

* Petty, G.W., 1995: Frequencies and characteristics of global oceanic precipitation from shipboard present-weather reports. *Bull. Amer. Meteor. Soc.* (to appear in September issue)

Petty, G.W., and D.K. Miller, 1995: Satellite microwave observations of precipitation correlated with intensification rate in extratropical oceanic cyclones. *Mon. Wea. Rev.* (in press)

Petty, G.W., 1995: The status of satellite-based rainfall estimation over land. *Remote Sens. Environ.* (to appear in Jan. issue), 13 pp. (invited paper)

Conference Papers

* Petty, G.W., and D.R. Stettner, 1994: A new inversion-based algorithm for retrieval of over-water rain rate from SSM/I multichannel imagery. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Oral presentation)

* Petty, G.W., A. Mugnai, and E.A. Smith, 1994: Reverse Monte Carlo simulations of microwave radiative transfer in realistic 3-D rain clouds. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Poster presentation)

* Petty, G.W., 1994: Some regional characteristics of oceanic rainfall and their implications for satellite rainfall retrievals. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Poster presentation)

* Petty, G.W., and M.D. Conner, 1994: Identification and classification of transient signatures in over-land SSM/I imagery. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (Poster presentation)

Petty, G.W., and D.K. Miller, 1994: SSM/I rainfall indices correlated with deepening rate in extratropical cyclones. *7th Conference on Satellite Meteorology and Oceanography*, Monterey, California, 6–10 June. (invited paper, oral presentation by D. Miller)